

Habituation and Cardiovascular Responses to the Gamercize Stepper in Hong Kong Chinese Girls

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Abstract

Objective: Contingent active videogame systems have been shown to result in increases in physical activity and decreases in sedentary behavior. The feasibility of using contingent active gaming systems (e.g., the videogame freezes when physical exertion ceases) as an activity alternative and whether these systems will elicit activity of moderate to vigorous intensity is unknown. We aimed to determine whether Hong Kong Chinese girls (8.5 ± 0.3 years old) would (1) easily habituate to stepping and playing videogames and (2) whether stepping and videogaming would result in cardiovascular responses beneficial to health.

Subjects and Methods: Basic anthropometric measures as well as peak oxygen uptake (VO_2) were assessed on the first of two laboratory visits. The girls were also given playing instructions for three Xbox 360 (Nintendo, Kyoto, Japan) games: "The Bee Movie," "Surfs Up," and "Kung Fu Panda." On the second laboratory visit, the girls completed a habituation protocol and a 15-minute play session on the Gamercize® (Databridge Services Ltd., Southampton, United Kingdom) Stepper™, during which cardiovascular effort was assessed using heart rate monitoring.

Results: Direct observation of the girls showed that four girls needed 90 seconds and 12 of the girls only required 60 seconds to habituate to the Gamercize Stepper. There was no significant difference ($t_{15} = -1.944$, $P > 0.05$) between the heart rate at 55 percent of peak VO_2 (144 ± 9 beats/minute) and heart rate during Gamercize stepping (139 ± 13 beats/minute), indicating that mean heart rates in both conditions were similar. Further analysis showed that 25 percent of the girls stepped and played videogames at a heart rate equivalent to moderate intensity.

Conclusions: Although the girls easily habituated to the Gamercize Stepper, a majority of the girls did not step and videogame at moderate intensity levels, which are associated with body composition changes. Further investigations are warranted to determine mediators responsible for increasing physical activity levels to meet current recommendations.

Background

GLOBALLY GIRLS ARE LESS ACTIVE than boys.¹ This phenomenon has been shown to begin as young as 8 years of age² and is further compounded as children age into adolescence.^{3,4} It is recommended that children accumulate 60 minutes of moderate to vigorous activity a day to maintain health,⁵ and some gender-specific guidelines suggest that girls should accumulate 120 minutes of activity daily.⁶ Yet, girls spend less time in moderate to vigorous levels of activity and more time sedentary than their male counterparts.⁷ In the United States, it is estimated that 45 percent of boys are meeting current physical activity guidelines but only 27 percent of girls are engaging in sufficient amount of physical activity.⁸ It appears that this phenomenon may partly be

driven by the gender inequalities that are apparent to young girls when participating in physical activity programs.^{3,9} For this reason, researchers and governments have appealed for interventions with an aim to increase the amount of time girls spend being physically active.¹⁰⁻¹²

Active videogame play has emerged as a popular innovative tool to engage children in physical activity and increase energy expenditure.¹³ Contingent active videogame systems (e.g., where the videogame play is contingent upon maintaining physical exertion) are of growing interest and have been shown to result in increases in physical activity and decreases in sedentary behavior.^{14,15} The Gamercize® (Databridge Services Ltd., Southampton, United Kingdom) Stepper™ allows children to play a videogame of their choice, but is contingent on continuous stepping. In other

words, when stepping is discontinued the videogame freezes, and videogame play ceases. The Gamercize system is compatible with various gaming consoles and for this reason is capable of offering many game choices, which can be tailored to individual preferences. The ability to offer a wide variety of game options and perform a motor activity that requires limited skill level appears to improve the reinforcing value of physical activity and increase exercise adherence.¹⁶ These are also attractive attributes for younger children who are easily bored and may not have appropriate cognitive or functional motor skills to play advanced games that require high cognitive and motor functions.

A previous study using pedometers to assess intensity of stepping and playing videogames on the Gamercize Stepper during recess indicated a lower step count for the control participants compared with intervention peers for week 1 of a 6-week intervention.¹⁷ Although no rationale was given for these findings, it is possible that the lack of habituation to simultaneously stepping and videogaming produced increased stepping cadence and was responsible for the children playing on the Gamercize Stepper to have a higher step count than those assigned to traditional recess activities. It is unclear whether primary school girls will easily balance and maintain control of the game when stepping and videogaming simultaneously and if contingent active gaming systems such as the Gamercize Stepper will elicit activity of an intensity beneficial to health.¹⁸

This preliminary study was designed to determine the feasibility of using the Gamercize Stepper in a population of Chinese girls 8–9 years of age and to determine the cardiovascular responses while playing and stepping. We chose girls 8–9 years old to investigate our hypotheses given the findings that girls are less active than boys and based on the knowledge that this phenomenon tracks over time.¹⁹ We hypothesized:

1. That the girls would easily balance and habituate when stepping and playing videogames on the Gamercize Stepper.
2. The cardiovascular response when stepping and playing videogames would be equivalent to moderate-intensity exercise.

Subjects and Methods

Participants

We recruited the girls in this study using letters of interest, which were sent through the school to all parents with girls 8–9 years of age. Informed written consent was obtained from parents of 22 girls attending a local government primary school in Hong Kong. Ethical approval was granted by the Institutional Review Board for human ethics. Medical history completed by the girls' parents indicated that all of the participants were healthy with no known illnesses or contraindications to exercise/physical activity. We excluded one child from the analyses because of her absence during the Gamercize Stepper session. Five of the children did not have complete datasets because of equipment failure during peak oxygen uptake (VO_2) assessment. Of the 16 children who finished the habituation protocol with complete datasets, 10 (62 percent) were considered overweight, and six (38 percent) were normal weight, based on local age- and sex-specific body mass index cutoffs.²⁰

Procedures

The girls visited our laboratory twice. The first visit consisted of anthropometric measures and peak VO_2 assessment. We determined peak VO_2 following a 12-hour fast and abstinence from exercise. During this visit, the girls were introduced to three Xbox 360 (Nintendo, Kyoto, Japan) games: "The Bee Movie," "Surfs Up," and "Kung Fu Panda." All three games are rated "E" (suitable for everyone) by the Entertainment Software Board.

On the second laboratory visit, the girls completed a habituation protocol and play session on the Gamercize Stepper, during which cardiovascular effort was assessed. The girls were freely offered the three Xbox 360 games—"The Bee Movie," "Surfs Up," and "Kung Fu Panda"—to choose as they liked. After choosing one of the three available Xbox 360 videogames, the girls began the habituation protocol. The girls began stepping without playing the videogame, with the stepper set on "Non-Contingent Gentle Cycle" mode. After 30 seconds of stepping, the girls were given the Xbox 360 game controller and began to play their chosen videogame. When the girls were comfortable with the Stepper and could manipulate the game without any disruption to stepping or the game, the contingency mode was switched on, and they continued on the Gamercize Stepper and played their chosen videogame for 15 minutes. Cardiovascular effort was assessed continuously using heart rate telemetry (model E600; Polar®, Woodbury, NY).

Measures

Body composition. Height was measured in the laboratory with the girls barefoot to an accuracy of 0.1 cm with a fixed stadiometer (model 2007246; Invicta, Leicester, United Kingdom). Body mass was determined in the laboratory with the girls wearing lightweight clothes (t-shirt and shorts), with an accuracy of 0.1 kg, using electronic scales (model TBF-410 body composition analyzer; Tanita®, Tokyo, Japan). Body mass index was calculated as body mass (kg) divided by height squared (m^2).

Peak VO_2 and maximum heart rate. Following a 10-minute seated resting period, submaximal and peak VO_2 values, as well as cardiovascular responses, were determined using an incremental treadmill protocol.²¹ The girls starting walking at 3.0 km/hour and increased speed every 4 minutes by 1.0 km/hour, until a respiratory exchange ratio of 0.90 was reached. Once respiratory exchange ratio values of 0.90 were attained, the remaining few minutes of the test were used to elicit peak VO_2 . Speed was increased to 8 km/hour for 1 minute, at which point the gradient was increased every minute by 2 percent until the child reached volitional maximum.

Peak VO_2 was determined when two of the following three conditions were reached: (1) a respiratory exchange ratio of >1.0 , (2) heart rate $>85\%$ of age-predicted maximum, and (3) the participant was exhausted and refused to carry on despite strong verbal encouragement.²¹ We used an indirect calorimeter (Ultima™; Medgraphics®, St. Paul, MN). Data were collected breath by breath and integrated to an eight-breath average. Prior to each test, gases of known concentration were used to calibrate the oxygen and carbon dioxide sensors. Calibration of the volume sensor was performed using a 3-l

syringe. The children wore a pediatric-sized Hans Rudolph (Shawnee, KS) mask (model 8950), which was checked for proper fit and leakage. Heart rate was monitored continuously from heart rate telemetry (Polar model E600).

Physiological effort during Gamercize. When the girls underwent the 15-minute Gamercize protocol, heart rate was measured continuously from heart rate telemetry (Polar model E600). We used our assessment of peak VO_2 and peak heart rate during the exercise test to compare with the heart rate assessed during the Gamercize session to provide individualized interpretation of cardiovascular responses during the Gamercize Stepper activity. As suggested by Gutin et al.,²² we used heart rate at 55 percent of peak VO_2 to determine moderate intensity, a level commensurate with changes in body composition.

Habituation and physiological effort during Gamercize Stepper. A researcher observed the 15-minute Gamercize Stepper session for each individual to evaluate ease of stepping and gaming, as well as balance control. Habituation was determined when stepping rate was constant, there was no disruption to videogame play, and balance was maintained without assistance from the researcher.

Data analysis

Means and standard deviations were computed for all variables. The physiological and cardiovascular responses during submaximal and maximal treadmill exercise, as well as the corresponding cardiovascular effort during Gamercize Stepper play, are reported for each participant. We used paired *t* tests to determine the difference between the heart rate at 55 percent peak VO_2 (moderate intensity) and the heart rate during Gamercize Stepper videogame play.

Results

Descriptive characteristics are shown in Table 1. In Table 2 mean values for heart rate, maximal heart rate, and peak VO_2 during the maximal treadmill test are reported. The physiological outcomes from the exercise test in this study were comparable to previous studies assessing peak VO_2 in Hong Kong girls.²¹ Table 3 provides individual as well as mean values for heart rate and 55 percent peak heart rate (moderate intensity) during Gamercize Stepper play. In Table 3 we also provide individual and mean values for heart rate percentage of peak VO_2 and peak heart rate determined during Gamercize Stepper play. There was no significant difference

TABLE 1. DESCRIPTIVE CHARACTERISTICS OF THE PARTICIPANTS

Characteristic	Mean \pm SD
Number of participants	18
Age (years)	8.5 \pm 0.3
Stature (cm)	133.2 \pm 6.0
Body mass (kg)	33.4 \pm 7.2
Waist (cm)	63.0 \pm 7.5
Body mass index (kg/m ²)	19 \pm 3.1

SD, standard deviation.

TABLE 2. HEART RATE, MAXIMAL HEART RATE, AND PEAK OXYGEN UPTAKE DURING THE MAXIMAL TREADMILL TEST

	Mean \pm SD
Number of participants	16
Heart rate (bpm) at	
5 km/hour	127 \pm 13
6 km/hour	141 \pm 14
8 km/hour	163 \pm 11
Maximal heart rate (bpm)	199 \pm 5
Peak VO_2 (mL/kg/minute)	42 \pm 4

bpm, beats/minute; SD, standard deviation; VO_2 , oxygen uptake.

($t_{15} = -1.960$, $P = 0.69$) between the mean heart rate at 55 percent peak VO_2 (145 \pm 10 beats/minute) and average heart rate during Gamercize stepping (139 \pm 13 beats/minute). Further analysis of the individualized data indicated that four (25 percent) of the girls stepped and played videogames at a heart rate equivalent to 55 percent of their peak VO_2 . Direct observation of the girls showed that four girls needed 90 seconds without contingent mode to habituate to videogaming while stepping. Twelve of the girls habituated to the Gamercize Stepper in the non-contingent mode within 60 seconds of videogame initiation.

Discussion

These preliminary findings show that 8–9-year-old Chinese girls easily habituate to the Gamercize Stepper. Direct observation revealed that all of the girls habituated to the Gamercize Stepper within 1.5 minutes and were able to play without disruption to videogame play, their balance, or stepping cadence. A barrier to physical activity for girls is that a majority of sports and exercise modalities require skills such

TABLE 3. INDIVIDUAL AND MEAN HEART RATE AND PERCENTAGE OF HEART RATE AND PEAK OXYGEN UPTAKE VALUES WHILE STEPPING AND PLAYING VIDEOGAMES

Participant number	HR (bpm)		Percentage of peak	
	Gamercize	At 55% peak VO_2	VO_2	HR
1	115	141	33	58
2	155	138	66	75
3	145	158	44	71
4	116	138	39	58
5	131	141	47	68
6	145	145	55	74
7	140	121	64	69
8	140	146	50	71
9	137	143	50	70
10	140	151	44	72
11	129	133	52	65
12	133	156	35	65
13	139	146	48	71
14	163	155	62	81
15	153	159	49	76
16	140	150	45	70
Total	139 \pm 13	145 \pm 10	49 \pm 9	70 \pm 6

bpm, beats/minute; HR, heart rate; VO_2 , oxygen uptake.

as strength, power, and speed,²³ which may be more difficult to learn and would require a longer time to master. An advantage of the Gamercize Stepper is the similarity to stair climbing, which as shown in our results enables the user to become easily adapted to the activity. In addition to the ease of habituation, all of the girls requested more time to play once the session was completed. This is not surprising given that one of the benefits of using contingent systems is the ability of the users to choose their game, which increases the possibility of adherence. Behavioral economics theory suggests that a closed-loop feedback approach to addressing physical inactivity may increase physical activity and decrease sedentary behavior.²⁴ Contingent active gaming systems include the closed feedback loop by implementing physical activity while offering children the ability to engage in their chosen activity.

Playing videogames while on the Gamercize Stepper elicited a mean heart rate of 139 beats/minute. Analysis from the maximal exercise test indicated this level of exertion is similar to treadmill walking at approximately 5–6 km/hour. Although these levels of activity are greater than sedentary activity pursuits, a majority of our participants did not reach levels commensurate with moderate physical activity levels reported to be associated with changes in body composition.²² Only four of the 16 girls stepped and played videogames at moderate-intensity levels. Our main focus was to determine whether the girls in this study would step and videogame at levels equivalent to moderate intensity. We did not encourage the girls, provide feedback, or set specific goals for them. It has been suggested that the acquisition of a game may need to be complemented with specific guidelines dependent on the desired outcome.²⁵ Findings from our lab also suggest that when given choice between sedentary videogaming and activity-enhanced videogame play, children choose to sit.²⁶ It appears from our current results that it may be necessary to provide the same feedback, monitoring, and prescribed goals when using contingent systems to promote physical activity to ensure that activity levels commensurate with health outcomes are met.

We used specific recommendations associated with fitness parameters and specific outcomes to determine the cardiovascular effort of stepping and gaming on the Gamercize Stepper. When the mean heart rate was examined, the percentage of peak VO_2 elicited from stepping and playing videogames fell short of meeting the recommendations for improving peak VO_2 .²⁷ The girls in our study stepped and played videogames at a heart rate of 49 percent of peak VO_2 . According to Armstrong et al.,²⁷ children should be exercising at 85–90 percent of maximum heart rate for 40–60 minutes three or four times a week to improve peak VO_2 and maximize aerobic fitness. Given that most girls do not meet basic physical activity recommendations, the dose and goal of prescribed activity may need to be reassessed when initially implementing active gaming interventions.

Our findings support the claim that some active games may not be effective in providing sufficient levels of activity to meet physical activity recommendations,²⁸ which suggest children participate in daily moderate-vigorous physical activity.²¹ According to Wei et al.,²⁸ variability in intensity levels exists among active gaming systems; as they noted, active games that require full body movements produce

higher-intensity levels than those that are restricted to upper or lower body movements, which may partly explain our results because the Gamercize Stepper only requires use of the lower body. As shown in the individualized data, some of the girls stepped and played the videogames at levels commensurate with the cutoffs noted to produce body composition changes,²² whereas others fell short of meeting these recommendations. It is also interesting to note that three of the four girls who met the moderate-intensity level when stepping and gaming were considered overweight. These results are promising given that overweight children are less likely to engage in moderate to vigorous levels of physical activity than their lean peers.^{29,30} It is apparent from our individualized data that monitoring and feedback are warranted when implementing active gaming physical activity programs. Further investigations into the type of feedback and monitoring needed to produce activity levels commensurate with recommendations are needed.

An advantage of this study is that we chose to individualize the data to showcase the interindividual differences in activity levels when stepping and gaming rather than using absolute levels, which may overestimate intensity levels. Although promising, our preliminary findings are not without limitations. The sample size in our study did not allow for analysis between variables such as weight status, and although not the aim of our study, it appears from our results that this may be an interesting area for further investigation. Because of the exploratory nature of our study, we were not able to track usage over time and determine sustainability. However, our primary aim was to determine ease of play (habituation) and to determine whether the girls stepped and played videogames commensurate with levels associated with health outcomes. These data will facilitate further research into using contingent active videogame systems and are therefore an important step to discovering the benefits of using active gaming as a physical activity alternative.

Acknowledgments

We are grateful to the participants and the primary school for assisting us with this research study. We would also like to acknowledge the generosity of Gamercize, which donated the equipment used in this study.

Author Disclosure Statement

Gamercize or representatives/employees of Gamercize were not involved in the study design, collection of data, analysis, interpretation of data, writing the manuscript, or the decision to submit the manuscript for publication. No competing financial interests exist.

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